ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1093.] **December 13th, 1922.** [Session 1922–23.

December 6th, 1922.

Prof. A. C. Seward, Sc.D., F.R.S., President, and afterwards, Mr. R. D. Oldham, Vice-President, in the Chair.

John Rickman Bourchier, Furze Reeds, Midhurst (Sussex); Charles Henry James Clayton, M.B.E., M.Inst.C.E., 53 Carlton Avenue, Dulwich, S.E. 21; William James Cousins, 2 Dorlcote Road, Wandsworth, S.W. 18; Leslie Reginald Cox, B.A., Assistant in the Department of Geology, British Museum (Natural History), 95 Mattison Road, Harringay, N. 4; Reginald Gordon Doyle, F.C.S., The Larches, 28 Newlands Park, S.E. 26; David Gibby, B.Sc., Glyn Llewellyn, Clynderwen (Pembrokeshire); Harry Cecil Haworth, B.Sc., 82 Leamington Road, Blackburn (Lancashire); George Arthur Hughes, 47 Thornhill Square, N. 1; Herbert Stanley Hunter, Thornton House, Hartburn, near Morpeth (Northumberland); Agnes Irene McDonald, M.Sc., Demonstrator in Geology in Bedford College, 103 Belgrave Road, S.W. 1; William Edward Frank Macmillan, 42 Onslow Square, S.W. 7; Sidney Leonard Mainprize, Wydale, St. John's Avenue, Bridlington (Yorkshire); Leslie Hamilton Ower, Government Geologist, Belize (British Honduras); the Hon. Hubert Lister Parker, B.A., Nether Worton House, Steeple Aston (Oxfordshire); George Henry Plowman, Boxmoor Road, Highfield Road, Southampton; Charles Murray Pollock, B.A., Harefield, Chaucer Road, Cambridge; George Scotland Sweeting, Imperial College of Science & Technology and 38 Pulborough Road, Wimbledon Park Road, S.W. 18; and John Walker Walton, L.D.S., Tower House, 16 Manor Road, Folkestone, were elected Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—The Senonian Ammonite-Fauna of Pondoland, by L. F. Spath, 1922; Memoirs of the Geological Survey of Ireland: Mineral Resources—Memoir & Map of Localities of Minerals of Economic Importance & Metalliferous

Mines in Ireland, by G. A. J. Cole, 1922. Also the following sheets of geological maps:—Geological Survey of Scotland, 6-inch map—Lanarkshire, Sheets XII N.E. & N.W., solid & drift; XII S.W., solid; VIII S.W., drift; VIII S.E., solid; IX N.W. & N.E., & IX*a* N.W., solid; XI S.E., solid; Geologische Kommission der Schweiz: Spezialkarte No. 95—Geologische Karte & Profile des Brienzergrates, 1:50,000, 1921; Spezialkarte No. 63—Karte der Alpen zwischen Linthgebiet & Rhein:—Flumser-Alpen, Graue Hörner, Ringelspitz, Calanda, 1:50,000, 1920; Geologische Karte von Mittelbünden, 1:25,000—Blatt A, Arosa, 1922; and Geologische Karte der Val Bregaglia (Bergell), 1:50,000, Editions A & B, 1921.

The following communications were read:—

1. 'Geological Investigations in the Falkland Islands.' By Herbert Arthur Baker, D.Sc., D.I.C., F.G.S.

The stratigraphical succession in the Falkland Islands comprises rocks of Archæan, Devono-Carboniferous, and Permo-Carboniferous age.

There is only one exposure of Archæan rocks in the Colony: namely, in the cliffs of Cape Meredith, the southernmost point of West Falkland. The rocks seen include various igneous types (pegmatite, granite, gneiss) and metamorphic rocks (hornblende-schist, quartzite). The pegmatite and schist are also invaded by lamprophyre-dykes.

Overlying these old rocks, and separated from them by a strong unconformity, are coarse sandstones and quartzitic rocks, nearly horizontal. This unfossiliferous series is of great thickness, probably about 5000 feet. It occupies the southern part of West Falkland as far north as Port Edgar and Port Richards, and also the islands lying to the west of this area. It is generally horizontal, or dips fairly gently northwards and eastwards. It is regarded as of Devonian age, and in its lithological characters shows remarkable similarity to the Table Mountain Series of the Cape Province, with which it is correlated.

The succeeding series of rocks of Devono-Carboniferous age occupy the remainder of West Falkland (except for small areas of Permo-Carboniferous rocks) and the northern half of East Falkland, and comprise strata correlated with the Bokkeveld and succeeding Witteberg Series of the Cape Province, to which they are notably similar in lithological character. The typical marine molluscan and crustacean fauna of the Bokkeveld Series is yielded by the middle Devono-Carboniferous series of the Falklands, and the succeeding beds are shales and quartzites, with poorly-preserved plant-remains, like the Witteberg Beds of the Cape of Good Hope. The Middle and Upper Series each include abont 2500 feet of strata.

Terrestrial deposits of Permo-Carboniferous age follow. They

occupy a synclinorium extending over the whole of the southern half of East Falkland (Lafonia) and Falkland Sound. They also occur in small, separate areas on West Falkland. The name 'Lafonian Formation' has been given to this set of beds by Dr. T. G. Halle. They include a thickness of strata exceeding 9000 feet.

As in the Southern Karroo, the lowest beds of this younger system are glacial boulder-beds. There is a tillite formation, about 2300 feet thick, in every way comparable with the Dwyka Tillite. Shaly beds occur locally between the boulder-beds and the older quartzite, but are often absent. There is a thin representative of the Upper Dwyka Shales of the Southern Karroo.

A sandstone formation (Lafonian Sandstone) of no great thickness follows, and is, in turn, succeeded by more than 6000 feet of terrestrial deposits. Several thousand feet of these Upper Lafonian Beds consist of a monotonous alternation of thin sandstones and shaly beds. They have yielded the *Glossopteris* Flora in several places. These upper beds appear to be the equivalent of the Ecca Series of the Southern Karroo. In view of their thickness, it is possible that some portion of the Beaufort Series of the Karroo System may be represented, but no evidence of this was obtained.

Doleritic dykes are of frequent occurrence. Their age is post-Upper Lafonian, since they are seen to cut the highest strata in the Colony.

With regard to the precise age of the marine Devonian fauna of the fossiliferous series of the older rocks, a difficulty arises. Palæontologists in general admit no more than that this fauna is of Devonian age. Some have insisted, however, that its age is Lower Devonian. The glacial boulder-beds at the base of the Permo-Carboniferous are now very generally regarded as of Upper Carboniferous age, and the Witteberg Beds of the Cape Province have recently been considered by Sir T. W. Edgeworth David as of highest Lower Carboniferous, and possibly, in part, Middle Carboniferous age. In the Cape Province and the Falkland Islands strata of Witteberg age can be traced downwards, without a break and without traversing an excessive thickness of strata, into the marine fossiliferous series. It seems likely that the marine fauna will prove to be of Upper Devonian age.

The Falkland Islands appear to owe their existence to the fact that they occur at the crossing-place of two sets of folding movements.

2. 'On a Collection of Fossil Plants from the Falkland Islands.' By Albert Charles Seward, Sc.D., F.R.S., Pres.G.S., and John Walton, B.A.

The collection of fossil plants submitted to the Authors for examination was made by Dr. H. A. Baker at several localities in East and West Falkland, and in Speedwell and George Islands (south of East Falkland). It includes a few fragments of

Lepidodendroid stems too imperfect for specific determination : an examination of the specimens and a comparison of some other plant-remains, previously described by Dr. T. G. Halle, with plants from other countries lead the Authors to suggest a Devonian age for the oldest plant-bearing beds.

Numerous examples of *Glossopteris* leaves were collected, especially in Lafonia, and these are referred to *Glossopteris indica* Schimper and *G. browniana* Brongniart, species which are not confined to one geological series in the Gondwana System. Many specimens of Equisetaceous stems were also obtained from the *Glossopteris* Beds : of these several are clearly identical with Falkland examples described by A. G. Nathorst and by T. G. Halle, while others are compared with an Upper Triassic or Rhætic species *Neocalamites carrerei* (Zeiller). The examination of some well-preserved wood from Choiseul Sound enables the Authors to amplify the account given by Halle, of wood which is closely allied to that discovered by Dr. Baker. A comparison of petrified wood, most of which has been assigned by various writers to the genus *Dadoxylon*, from different parts of Gondwanaland, points to the prevalence in the southern botanical province of trees differing in certain anatomical characters from contemporary plants in the northern province. The present Authors' conclusion is that the Permo-Carboniferous flora as a whole, so far as it is possible to base an opinion on the few species represented, agrees most nearly with the Damuda and Beaufort Series of India and South Africa respectively. The stems compared with *Neocalamites* favour a reference of the beds at Cygnet Harbour and Egg Harbour to a somewhat higher position ; and, on the other hand, the leaves described as *Glossopteris indica* Schimper (cf. *G. decipiens* Feistmantel) from North Arm, although they represent a type which has a wide range both in space and in time, suggest a possible correlation with the Ecca Series of South Africa and the Talchir Series of India.

Rock-specimens, fossils, microscope-slides, and lantern-slides were exhibited in illustration of the foregoing papers.

The next Meeting of the Society will be held on Wednesday, December 20th, 1922, at 5.30 P.M., when the following communications will be read :—

1. 'A Micrometric Study of the St. Austell Granite (Cornwall).' By W. A. Richardson, M.Sc., F.G.S.

2. 'The Petrography and Correlation of the Igneous Rocks of the Torquay Promontory.' By W. G. Shannon, M.Sc., F.G.S.

Prof. O. T. JONES will give a demonstration of the Crystallization of a Doubly-Refracting Liquid.

Robert Bleeck, A.R.S.M., Petroleum Geologist, 20 Liverpool Road, Kingston Hill (Surrey); Wilfred Norman Edwards, B.A., Assistant in the Geological Department of the British Museum (Natural History), 26 High Oak Road, Welwyn (Hertfordshire); Charles Frederick Pilcher, Schoolmaster, 122 Windsor Road, Forest Gate, E. 7; and Ernest Bowes Tyrrell, B.A., Schoolmaster, 17 Camden Terrace, Clifton Vale, Bristol, will be balloted for as Fellows of the Society.

Fellows are requested to send in to the Secretaries, so as to reach them not later than January 8th next, the Names of any Fellows whom they desire to see placed on the Council.

The List of Geological Literature added to the Society's Library during 1914, with subject-index, will probably be published at the New Year (price 2s. 6d. to Fellows); and the List of Geological Literature for 1915–19, with subject-index, will be issued later in 1923 (price 7s. 6d. to Fellows). Those Fellows who wish to purchase either or both of these publications are requested to send in as soon as possible their orders for the same, together with a remittance for the amount payable, to the Clerk, Geological Society, Burlington House, London, W. 1.

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Geology

ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1113.] **February 13th, 1924.** [Session 1923-24.

February 6th, 1924.

Prof. A. C. Seward, Sc.D., F.R.S., President, in the Chair.

Douglas Wallace Bishopp, A.R.S.M., Mazapil Copper Company, Aranzazu, Concepcion del Oro, Zacatecas (Mexico); William Ion Collins, B.Sc., 18 High Street, Northfleet (Kent); and Harold William Cornes, B.Sc., 25 Macdonald Road, Friern Barnet, N. 11, were proposed as Fellows of the Society.

Frank Smithson, B.Sc., 24 Milton Street, Darlington; and David Mowat Watson, B.Sc., 46 Featherstone Road, King's Heath, Birmingham, were elected Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—Extinct Plants & Problems of Evolution, by D. H. Scott, 1924; The Pliocene Mollusca of Great Britain, Vol. ii, pt. 3, by F. W. Harmer, 1923; A Monograph of the Ammonoidea of the Gault, pt. 1, by L. F. Spath, 1923; and Imperial Institute Monographs—Cobalt-Ores, by E. Halse, 1924; Vanadium-Ores, 1924.

The following communication was read:—

'The Upper Towy Drainage-System.' By Prof. Owen Thomas Jones, M.A., D.Sc., F.G.S.

The paper gives an account of the physical and main geological features of the upper part of the Towy drainage-system. The floors of the Towy valley and of its principal tributaries (the Camddwr and Pysgotwr) were levelled, in order to obtain data for constructing their longitudinal profiles. A few level[illegible] were also

determined in the upper valley of the Cothi, which formerly entered the Towy valley many miles above its present mouth.

The Towy valley, for about 8 miles from the source, is fairly wide, and the opposing spurs, which usually are gently convex, are set well apart; the longitudinal profile is concave, and the lower ends of the tributary valleys are graded with the main valley. The features are those of a fully mature drainage-system. Above Fanog ($8\frac{1}{2}$ miles) the floor of the valley is trenched by a narrow ravine, which develops into a deep glen gradually widening downstream. Between Rhandirmwyn (15 miles) and Llandovery (22 miles) the valley presents once more a mature appearance, which it retains as far as its mouth (56 miles) below Carmarthen. The whole longitudinal profile thus consists of two concave portions, in each of which the gradient diminishes progressively downstream, separated by a short stretch with high and irregular gradient.

The upper part of the valley is attributed to a former period of base-levelling. This was followed by a rejuvenation of the drainage-system due to an uplift of the area. The present valley between Rhandirmwyn and the mouth was eroded in consequence of that rejuvenation, and is base-levelled or graded in relation to the existing sea-level. The upper or Fanog base-level, as it is termed, to which the upper part of the valley conforms, now stands much above the present sea-level. A formula was sought and found to which the profile above Fanog conforms; also the height of the Fanog base-level at the present mouth of the Towy was determined by calculation from the formula, and by comparison with the profile and gradient of the valley below Llandovery. These determinations show a difference of approximately 400 feet between the former and the existing base-levels.

The tributary valleys afford confirmation of the results obtained in the main valley. About half a mile above Nant Stalwyn (5 miles) there is a well-marked drop or step in the rock-floor of the Towy valley. Below this step the tributary valleys hang above the main valley-floor, the discordance increasing downstream. The association of a rock-step with hanging valleys below is often regarded as evidence of Glacial erosion with overdeepening of the main valley: but, in this locality, there is conclusive evidence that the hanging tributaries are pre-Glacial. The most probable explanation of these features is that they are due to a still earlier uplift of the region, followed by rejuvenation of the valley up to the rock-step. This suggestion is borne out by the features of the tributary valleys for many miles downstream.

The part of the valley above the rock-step was, therefore, eroded in relation to a base-level older than the Fanog base-level. This, which is termed the Nant Stalwyn base-level, is estimated to stand at present nearly 600 feet above the level of the sea.

The investigation has also thrown light on past changes in the drainage-system, and may ultimately help to solve the problem of the age and origin of the great plateau of Central Wales.

Discussion.

Dr. A. Morley Davies expressed his great interest in the paper. The two uplifts of which evidence had been adduced were on a much larger scale than the post-Glacial uplifts recognized in the Thames Valley, and must evidently date back to at least Pliocene time. This raised the question as to possible diversions of the river-system, and he enquired as to the probability of the Towy having originally flowed through the Llandeilo wind-gap.

Mr. G. W. Lamplugh remarked that several valleys in the Isle of Man showed features similar to those described. He suggested that the position of the mid-way gorge was usually in part determined by the space required as a gathering-ground before the stream gained sufficient volume to become effective under present conditions of diminished precipitation. In drift-cumbered upper basins the feeble headwaters were frequently incapable of shifting residual boulders, which accumulated and protected their beds. The Author's method of research was likely to yield great results, but the factors involved were numerous.

Dr. J. A. Douglas congratulated the Author on his paper, and said that it was not merely of interest to those who possessed an intimate local knowledge of the district, but involved principles that were of world-wide application. The Author's description of the rock-steps of the Towy valley reminded the speaker of certain high-level valleys in the Peruvian Cordilleras, which exhibited a similar series of rock-steps. He had formerly been led to consider these as phenomena due to glacial erosion; but this paper had suggested a new line of reasoning, and he now felt tempted to regard them as marks of successive uplifts passing one after the other up the valleys in question. Eventually, it might be found possible to correlate these with the raised beaches of the coast. These rock-steps or sudden changes of grade would work their way backwards from mouth to source up main and tributary valleys alike. The greater erosive power of the main stream, however, would tend to obliterate them more rapidly than in the tributary valleys, and it was, therefore, in the latter that their more complete record would be preserved.

Mr. S. W. Wooldridge thought that the paper would re-awaken interest in river-problems in this country. The work of the late Joseph Bassett had shown that important results might be expected from a close scrutiny of physiographic profiles. Nevertheless, British workers had been slow in following the lead given to them by Prof. W. M. Davis in his well-known publications, now thirty years old. Prof. Davis had maintained that the British area yielded evidence of two distinct cycles of denudation, the first culminating in peneplanation. The present Author's conclusions seemed compatible with this suggestion, although they could scarcely be said to bear directly on the question.

It was a significant fact that a change of base-level, amounting to about 400 feet, had affected not only Central Wales, but regions

so widely separated as Cornwall, Aberdeenshire, and the London area. Hence it seemed likely that rejuvenation was caused by eustatic movements of sea-level, rather than by crust-warping.

The existence in the area studied of hanging tributaries, the formation of which antedated the period of glaciation, afforded an interesting confirmation of Prof. J. W. Gregory's contention that certain hanging valleys in Arran and elsewhere were not caused by glacial over-deepening. It was becoming increasingly clear that the importance of the glacial factor in the formation of such valleys had been overestimated in the past.

The Author replied that the amounts of the uplift responsible for the rejuvenation of the district were stated in the paper to be about 400 feet and 580 feet respectively. It was not possible, from the evidence in the region studied, to assign any date to the periods of the uplift. It was tempting to correlate the later uplift of 400 feet with that recognized in Devon and Cornwall; but, owing to the difference in the length of the valleys affected by rejuvenation in the two regions, it was premature to assign them to the same period of uplift. With regard to the course of the Towy in the lower part of the valley it was possible, as Dr. Davies suggested, that the river formerly went through the wind-gap at Llandeilo; but the distance to Carmarthen Bay by either course would be about the same, and would not sensibly affect the change of base-level indicated by the profiles of the upper part of the valley. There are, below Llandeilo, other wind-gaps which are as yet unexplained: they stand opposite to several streams, which drain into the Towy valley from the north, and appear to indicate that at one period the drainage of the region was mainly from north-west to south-east across the trend of the present Towy valley. These features require further investigation.

It was not surprising to learn from Mr. Lamplugh that the features observed by him in the Isle of Man were very similar to those of Central Wales, as (in all probability) the physiographical history of the two regions was somewhat similar. With regard to a large volume being necessary before a stream can start cutting into its channel, this did not seem to be borne out in the district, since quite small streams have cut ravines and glens which are more or less proportional to their size. The probability of the ancient valleys having been eroded under climatic conditions different from the present was discussed in the paper, and the conclusion reached that, while the rainfall may have been smaller, the load of the streams probably consisted of materials of finer grain: and, the effects of these two factors being in opposite directions, it was assumed provisionally that they cancel one another.

The evidence that the tributary valleys were, in the main, of pre-Glacial age seemed to be unquestionable; and, although the main valley has been glaciated, the glacial striæ point in places across the valley, so that probably but little erosion was brought about by glaciation. In general, if a series of rejuvenations followed one

another up the main valley, one might expect to find corresponding rock-steps in the tributary valleys; and, if the tributary streams are small in proportion to the main stream, the rock-steps might persist after those in the main valley had been obliterated.

The possibility that regional tilting of the area had occurred was discussed in the paper, but evidence for this must be sought in a lower part of the valley. If it were found that an uplift of about 400 feet could be established in widely different parts of the country, this seemed to point to eustatic movements. If the movement were of this kind, the reconstruction of this and other drainage-systems by the method suggested could be carried out with more confidence.

The next Ordinary Meeting of the Society will be held on Wednesday, February 27th, 1924, at 5.30 P.M., when the following communication will be read:—

'Age and Origin of the Lough Neagh Clays.' By W. B. Wright, B.A., F.G.S.

Edward Patrick Corbett-Sullivan, 83 Queen's Gate, S.W. 7; David Hartley Foster, B.Sc., 5 Frederick Road, Wylde Green, Birmingham; Mabel Elizabeth Tomlinson, B.A., M.Sc., Polesworth, Tamworth (Staffordshire); and Howel Williams, B.A., M.Sc., 188 High Park Street, Liverpool, will be balloted for as Fellows of the Society.

The Annual General Meeting of the Society will be held on Friday, February 15th, at 3 p.m. The Fellows of the Society and their friends will dine at the Café Royal (Regent Street, W. 1) on the same day at 7.15 for 7.30 p.m.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1116.] **March 20th, 1924.** [Session 1923–24.

March 12th, 1924.

Prof. W. W. Watts, Sc.D., F.R.S., Vice-President, in the Chair.

Douglas Wallace Bishopp, A.R.S.M., Mazapil Copper Company, Aranzazu, Concepcion del Oro, Zacatecas (Mexico); William Ion Collins, B.Sc., 18 High Street, Northfleet (Kent); and Harold William Cornes, B.Sc., 25 Macdonald Road, Friern Barnet, N. 11, were elected Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—Elementary Crystallography, by J. W. Evans & G. McDonald Davies, 1924; Memoirs of the Geological Survey, Scotland: Explanation of Sheets 86 & 96—The Geology of the Country round Banff, Huntly, & Turriff (Lower Banffshire & North-West Aberdeenshire), by H. H. Read, 1923; Facts about Peat, by B. F. Haanel, 1924; The Mineral Resources of Bulgaria, by D. A. Wray, 1924; The Pre-Cambrian System in Western Australia, by E. de C. Clarke, 1923; and British (*Terra Nova*) Antarctic Expedition, 1910–13: Report on the Maps & Surveys, by F. Debenham, 1923. Also, Geological Survey of Scotland: 1-inch Maps, Sheets 86 (Huntly) and 96 (Banff), 1923.

The following communications were read:—

1. 'Descriptions of Gasteropoda, chiefly in the late Mrs. Robert Gray's Collection, from the Ordovician and Lower Silurian of Girvan.' By Jane Longstaff (*née* Donald), F.L.S., F.G.S.

Since this paper deals especially with some of the gasteropoda contained in the magnificent collection of the late Mrs. Robert

Gray, others are only mentioned where they afford further information concerning structure or distribution. Forty-one forms are dealt with, of which one has been named in manuscript, and seven have been described by previous authors.

By far the greater number: namely, twenty-five species and one variety, belong to the Pleurotomariidae; of these twenty-one are new to science, and for two of the species a new subgenus is suggested.

The absence of the genus *Raphistoma* Hall is remarked on, and three species previously placed in it are transferred to *Liospira* Ulrich, as the possession of a sinual band distinguishes them from members of the former. A new species is also referred here.

Besides these Pleurotomarians, four new species belonging to three subgenera of the Loxonematidæ are described; two of the latter are new to science.

Also two species of the genus *Maclurea* are described, one new; four of *Eccyliomphalus*, two new; two of *Lesueurilla*, both new; one of *Euomphalopterus*, previously undescribed; and two of *Clisospira*, which are not only species new to science, but the genus itself does not appear to have been recorded before from the British Isles. One of these is sufficiently well preserved to give evidence of the peculiar characteristics of the sutural divisions.

2. 'The Old Red Sandstone of the Cardiff District.' By Albert Heard, M.Sc., F.G.S., and Richard Davies, M.Sc.

This paper gives an account of an exhaustive petrological investigation of the Old Red Sandstone of the Cardiff District. During the course of the work, a new fish-band was discovered in the Red Marl Group. This Coed-y-Coedcae Fish-Bed contains innumerable fragments of *Cephalaspis* and *Pteraspis*, together with *Pachytheca* and obscure plant-remains.

The petrological investigation revealed a rich assemblage of pebbles and minerals. Among the pebbles, vein-quartz and opalescent quartz are the most abundant, with numerous acicular, irregular, and especially regular inclusions. Evidence of intense mechanical deformation is generally exhibited. Cherts, jaspers, and pebbles of quartz-gneisses, mica-schists, sandstones, and quartzites are abundant. Pebble-beds, with sandstone-pebbles not assignable to any Lower Palæozoic sediments, are of common occurrence in the Red Marl Group. The finer constituents include quartz-grains similar to larger quartz-pebbles, abundant fresh microcline and oligoclase, and many large flakes of white mica and chlorite; fresh biotite occurs in the cornstones.

The 'heavy' minerals include ilmenite and leucoxene, pyrites, garnet, tourmaline, a large proportion of coloured to colourless zircons, rutile, apatite, and a little magnetite.

Three definite mineralogical zones are established, corresponding roughly with the stratigraphical groups.

The cornstones have been investigated, and partial chemical analyses made. A physico-chemical origin is suggested.

The sediments are compared with the Torridonian and Millstone Grit of Yorkshire, and it is concluded that the Old Red Sandstone of the Cardiff district represents estuarine and deltaic deposits derived mainly from a pre-Cambrian massif on the north-west.

The Silurian rocks of the Cardiff district have been investigated, and have proved to be entirely different and distinct from the Old Red Sandstone. No pebbles from the Silurian have been observed in the lowest Old Red Sandstone beds. It is concluded that the definite petrological break represents a non-sequence. The hypothesis of the 'Welsh Lake' is considered to be untenable.

A probable connexion with the Devonian of North Devon is suggested.

Discussion.

Mr. E. E. L. Dixon remarked that, as regarded the relations of the Old Red to the Silurian, the development in Southern Pembrokeshire marked an advance on the non-sequence suggested in the Cardiff district, and also supported the view, most recently expressed by Prof. L. D. Stamp, that, at various places in England and Wales, certain beds near the junction, though resembling the Silurian in some elements of their fauna, should be included in the Devonian. For, in the country around Pembroke and Tenby, the base of the Old Red contains frequent *Lingula*, a survivor of the Silurian fauna, but at the same time rests on the Ludlow unconformably. The junction is marked by a strong conglomerate of quartzites, quartzitic sandstones, and vein-quartzes, in which the felspathic material, abundant above, is rare.

On the other hand, the conclusions reached in Pembrokeshire as to the presence of land away to the south appeared to differ from those inferred from the Cardiff evidence. In this respect, the Lower Palæozoic and the Lower Old Red of Pembrokeshire differ from the Upper Old Red, which thickens greatly southwards, and, at several places in the southernmost outcrops, contains marine (Upper Devonian) intercalations; it has presumably formed part of a delta fringing the Devonian sea. The Lower Old Red and older rocks, on the contrary, yield evidence of the presence of land on the south. Thus, in Southern Pembrokeshire the Llanvirn Series is generally succeeded unconformably by the Ludlow, whereas on the north this hiatus is bridged, except for the break between the Lower and the Upper Llandovery. Again, north of Milford Haven, the Wenlock Series passes up into the Ludlow, and the latter, at most places, into the Old Red. On the south the Wenlock is separable from the Ludlow by a sharp line; the base of the Ludlow is conglomeratic and, in the southernmost outcrop, contains plant-beds without marine organisms. Moreover, the hiatus between the Ludlow and the Old Red increases on the whole

southwards. The Ludlow is overstepped, and probably there is also overlap of the base of the Old Red.

The bulk of the material of the Lower Old Red may well have been derived, as stated by the Authors, from pre-Cambrian rocks, for strained quartz and fresh felspars are abundant, and Dr. Herbert H. Thomas has found some of the Cosheston Sandstones abnormally rich in garnet. The pebbles of sedimentary rocks can hardly, however, have come a great distance: they are abundant, and reach diameters of 18 inches in the basal conglomerate. In the Ridgeway Conglomerate, which appears to be represented in the Cardiff district by the Llanishen Conglomerate, their large size and their abundance, to the exclusion of any coarse felspar-bearing fragments, point to an origin that was close to Pembrokeshire, and can hardly have been far from Cardiff. A few have yielded horny brachiopods, and are possibly Cambrian; but nothing like these fossiliferous rocks is known in South Wales *in situ*. It is difficult to avoid the conclusion that their source is now covered by the sea, and lies, partly at least, away to the south.

Mr. A. K. Wells regretted the unavoidable absence of the President, especially in view of the opinions expressed by the previous speaker. As a member of the Geologists' Association he had had the privilege of attending the excursion conducted by Dr. Evans in North Devon in 1922, and had been much impressed by the remarkable threefold alternation of marine with 'continental' deposits there developed. The succession is essentially intermediate in character between that of South Devon (marine) and that of South Wales (continental). The beds of continental facies in North Devon must increase in thickness northwards at the expense of the marine wedges, and merge into one thick continental series somewhere in the Bristol Channel. There thus appears to be neither room nor reason for the alleged ridge during the Devonian Period.

With regard to the pebbles and fragments in the Old Red Sandstone of the Cardiff district, he enquired whether it was not possible for some of these to have been derived second-hand from the Cambrian beds of the Harlech Dome, say, from the Rhinog and Barmouth Grits. Some of the rock-types could be matched in the Basement Series of the Ordovician of Merioneth, which the speaker believes to be, in part at least, redistributed Harlech material.

Dr. A. Morley Davies pointed out that the evidence for what the Authors termed a 'petrological non-sequence' was not quite analogous with the palæontological evidence of a non-sequence. If the change in the mineral contents of sediments were due to the gradual removal of overlying rocks and the increased exposure of a deeper series, abruptness in the change would certainly seem to indicate a time-interval unrepresented by sediments. But, if the change were due to an alteration in the direction of transport of minerals, abruptness was not necessarily inconsistent with continuous deposition.

Prof. A. Hubert Cox remarked that the paper afforded one

more instance that a petrological examination might shed new light on the origin of a sedimentary formation. To himself the present results were rather unexpected, but the evidence was so conclusive as to leave no room for doubt that pre-Cambrian rocks had contributed very largely to the Old Red deposits, and that Palæozoic formations had not contributed so largely as might have been expected. He was much interested in Mr. Dixon's remarks, because he had recently examined new exposures of what he believed to be the Llanishen Conglomerate, in excavations for the Wenallt Reservoir near Cardiff. The pebble-beds do not compare in thickness with the 1000 feet of the Ridgeway Conglomerate; but the pebbles themselves answer closely to the description just given by Mr. Dixon. They are mostly coloured quartzites, which he had failed to match with any Lower Palæozoic rocks, but occasional pebbles of coarser grain resembled some of the Lower Cambrian grits of North Wales, such as the Bronllwyd Grit. He had not obtained any derived fossils; but the suggestion of a Lower Cambrian derivation received additional support from Mr. Dixon's record of forms like *Kutorgina* from the Ridgeway Conglomerate.

The Secretary read the following contribution to the Discussion sent by Prof. P. G. H. Boswell:—

'I very much regret my inability to be present at the reading of the paper. Having some slight knowledge of the petrographical characters of the Devonian deposits north and south of the area considered by the Authors, I am interested to see that they find themselves compelled to turn to the north-west for the source of the material, and to exclude the older Palæozoic sediments. Speaking generally, in this conclusion I think they are correct. Both the coarser and the finer constituents which they describe suggest a source in pre-Cambrian (probably Archæan) rocks. The assemblage of strained-quartz, chlorite, tourmaline, garnet, and microcline is characteristic; it would be interesting to know whether large rose-purple ovoid zircons find a place in it. The pre-Cambrian types exposed in the Malverns, Shropshire, and Pembrokeshire are not competent to yield such an association; but it should be remembered that the petrological investigation of those rocks has not yet been intensively investigated. One feels a great temptation to turn to the Carnarvonshire area, where the Archæan of Anglesey would satisfy the demands. It is, however, important to remember that ancient massifs exposed in Devonian times may now be covered by later deposits.

'That the Authors are correct in stating that older Palæozoic rocks would not yield the assemblage, I do not doubt. The influence of the Archæan rocks on the petrology of the Algonkian sediments is well known. Thereafter, throughout the Cambrian, Ordovician, and Silurian Periods, the abundance and variety of the detrital minerals in the corresponding British sediments steadily decreases, until, when the basin of deposition was almost filled in later Ludlow times, the assemblage was dull in the extreme. Subsequent earth-movements resulted in an area of ancient and crystalline rocks being once again drawn upon to provide the early Devonian sediments. As was the case repeatedly in the geological history of these islands, the "Old Boy," to use Lapworth's homely, illuminating and, in this connexion, peculiarly appropriate term, was time after time the father of British sediments.'

Prof. W. J. Sollas recognized the importance of the results which the Authors had brought before the Society. He desired,

however, additional information on the mode of occurrence of the dodecahedral cleavage in garnets. He had never observed cleavage in thin slices of garnets, and thought that its presence under other conditions, though frequently asserted, might be open to other interpretations.

A petrographical break scarcely implied a stratigraphical unconformity, although it might well mark a change in physical conditions. In the neighbourhood of Cardiff there was, to all appearance, a gradual passage from the Silurian to the Old Red Sandstone, and this was true also of the succession so finely displayed on the northern side of the area in the Sawdde section.

Mr. W. Campbell Smith and the Chairman also spoke.

Mr. Heard, replying on behalf of the Authors, was glad to know that Prof. Boswell had arrived at similar conclusions, with regard to the Old Red Sandstone of certain other areas.

Prof. Cox had already referred to the Llanishen Conglomerate mentioned by Mr. Dixon, and a detailed account of this conglomerate is contained in the paper.

The views, as to the relation of the Old Red Sandstone of South Wales and the Devonian of Somerset which Mr. Wells had put forward, were essentially those held by the Authors. The paper attempted to show the important part played by pre-Cambrian rocks, in furnishing directly sediments to the Old Red deposits The Authors do not deny the possibility of some of the material having been derived from other rocks.

In reply to Dr. Morley Davies, Mr. Heard said that the term non-sequence was so well-known as implying the absence of certain strata, due to penecontemporaneous erosion, that the Authors felt justified in using it, even in a case where the non-sequence has not been proved by palæontological evidence. Conglomerates are not confined to one or even two horizons. Besides the main conglomerate bands, fine quartz-conglomerates also occur at the base of the Old Red Sandstone, as well as in the Coed-y-Coedcae Fish-Bed.

He thanked Prof. Sollas for his kindly criticism, and was interested in the occurrence of garnets with a well-marked parting in certain schists.

He felt that the hypothesis of a 'Welsh Lake' had filled a useful purpose; but the evidence in the Cardiff district was, that there was no ridge which could have separated such a lake from the marine area of Somerset.

Specimens of Ordovician and Lower Silurian Gasteropoda were exhibited by H.M. Geological Survey and by the Geological Department of the British Museum (Natural History), on behalf of Mrs. Jane Longstaff.

The next Meeting of the Society will be held on Wednesday, March 26th, 1924, at 5.30 P.M., when the following communications will be read:—

1. 'The Fossil Elephants of the Upper Thames Basin.' By K. S. Sandford, Ph.D., B.A., F.G.S.
2. 'Some Upper Viséan Caninid Corals.' By H. P. Lewis, B.A., F.R.S.

Agnes Elizabeth Bamber, M.Sc., 14 Watkin Terrace, Northampton; Leonard Charles Coe, B.Sc., Ringwood, Kingsland Road, Worthing; John Hancock, B.Sc., Lane Ends, Sandwell Street, Walsall (Staffordshire); and Gordon Murray Stockley, A.R.C.S., A.I.C., Geological Survey, c/o Public Works Office, Kingston, Jamaica (B.W.I.) will be balloted for as Fellows of the Society.

No. 317 of the Society's Quarterly Journal, Part 1 of Vol. LXXX, for 1924, now in course of issue, contains the following papers:—

1. Dr. S. H. Haughton on Reptilian Remains from the Karroo Beds of East Africa.
2. Prof. L. Dollo & Dr. P. Teilhard de Chardin on the Paleocene Mammalia of Belgium [in French].
3. Dr. H. Bolton on *Drybrookia cubitalis* from the Coal Measures of the Forest of Dean.
4. Dr. C. E. Tilley on Contact-Metamorphism in the Comrie Area of the Perthshire Highlands.
5. Mr. J. F. N. Green on the Structure of the Bowmore-Portaskaig District of Islay.
6. Prof. S. H. Reynolds on the Igneous Rocks of the Tortworth Inlier.

DANIEL-PIDGEON FUND.

On March 26th, the Council propose to make an award of the sum now in their hands, amounting to £30 (or thereabouts) to a candidate of either sex, who must not be more than 28 years or less than 21 years of age, and who is prepared to undertake some work of Geological Original Research.

The prescribed form of application can be obtained from the Permanent Secretary.

The Council wish to call the attention of the Fellows to the 'Gloyne Outdoor Geological Research Fund', the Regulations concerning which are obtainable on application to the

Permanent Secretary. The Fund is to be applied to the payment for actual work done in the field (excavations, etc.), but not to the reimbursement of personal expenses. The amount of income at present available is about £40.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1122.] July 4th, 1924. [Session 1923–24.

June 25th, 1924.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

George Hulme Hubbard, B.Sc., c/o the Anglo-Persian Oil Company, Ltd., Mohammerah (Persian Gulf); John Joseph Rowe, B.Sc., c/o the Niger Company (Mining Department), Tudun Wadia, Jos (Northern Nigeria); and Benjamin Seymour Redmayne Schofield, B.A., 119 East 19th Street, New York City (U.S.A.), were proposed as Fellows of the Society.

Robert Ashley Baldry, B.A., Lobitos, Paita (Peru); James William Pardoe, A.K.C., Ivanhoe, Boundary Road, Wood Green, N. 22; and Donald Parkinson, B.Sc., 61 West View, Clitheroe (Lancashire), were elected Fellows of the Society.

The Names of certain Fellows of the Society were read out for the first time, in conformity with the Bye-Laws, Sect. VI, Art. 5, in consequence of the non-payment of the arrears of their Annual Contributions.

The List of Donations to the Library was read; it included, among others, the following works:—Bristol Geology & Geography, by S. H. Reynolds, 1924; Aperçu sur la Géologie du Massif du Mont-Blanc & des Aiguilles Rouges, by L. W. Collet, 1924; Handbooks to the Exhibition of Pure Science, British Empire Exhibition, 1924; The Fauna & Stratigraphy of the Stormberg Series, by S. H. Haughton, 1924; The Density of the Earth as Calculated from the Densities of Mauna Kea & Haleakala, by H. S. Washington, 1923; and The Structural Geology of British Malaya, by J. B. Scrivenor, 1923.

The following communications were read :—

1. 'The River-Deposits of the Lower Valley of the Warwickshire Avon.' By Miss Mabel Elizabeth Tomlinson, B.A., M.Sc., F.G.S.; with an Appendix by Alfred Santer Kennard, A.L.S., F.G.S. & Bernard Barham Woodward, F.L.S., F.G.S.

Fluviatile sands and gravels occur as river-terraces in the lower valley of the Warwickshire Avon, between Stratford and Tewkesbury. The surfaces of these terraces lie on curves parallel to the present thalweg of the Avon. Five such terraces have been identified :—

No. 5 Terrace, about 140 to 150 feet above the river.
No. 4 Terrace, about 80 to 90 feet above the river.
No. 3 Terrace, about 40 to 50 feet above the river.
No. 2 Terrace, about 30 to 40 feet above the river.
No. 1 Terrace, not more than 10 feet above the river.

The heights refer to the surface of the river-terraces, for the following reason :—Deep excavations of the valley, followed by big infillings, have taken place at least twice in the history of the Avon Valley.

In the case of No. 5 and No. 4 Terraces, the deposits vary in thickness from 5 to 50 feet, according to whether the remnant of so big an infilling has been preserved towards the side or towards the centre of the ancient valley. No. 5 Terrace has yielded no contemporaneous fossils.

No. 4 and No. 3 Terraces both contain a warm fauna, with *Hippopotamus* and *Belgrandia marginata* occurring solely at No. 3 level, and *Corbicula fluminalis* at No. 4 level. The Author considers that No. 4 and No. 3 Terraces probably belong to the same period of aggradation; that No. 3 Terrace represents the early, and No. 4 Terrace the late stage in this aggradation, and that the terrace-like tops seen in some of No. 3 Terrace deposits were formed during a pause in the subsequent excavation of the valley through this big infilling.

No. 2 Terrace contains a cold fauna, with numerous remains of Mammoth and *Rhinoceros tichorhinus*.

No. 1 Terrace probably underlies the alluvium, and may be connected with the infilling of the buried channel which has been identified at Fladbury and Tewkesbury.

The sole evidence of human industry found in these deposits, up to the present, is a fresh flint of Mousterian type from No. 2 Terrace.

In the paper an attempt is made to reconstruct the history of the cutting of the valley of the Avon and to compare the results with those obtained in the Cam[1] and the Somme Valleys.[2]

[1] J. E. Marr, 'The Pleistocene Deposits around Cambridge' Q. J. G. S. vol. lxxv (1919–20) p. 204.

[2] L. de Lamothe, 'Les Ancienne Nappes Alluviales & Lignes de Rivage du Bassin de la Somme & leurs Rapports avec celles de la Méditerranée Occidentale' Bull. Soc. Géol. France, ser. 4, vol. xviii (1918) p. 3.

Discussion.

Prof. F. Schaffer remarked that the altitude of the highest terraces of the Avon and their agreement with those of the Somme recall the similar occurrences in Northern Africa, and in Southern and Central Europe. The cause has not yet been ascertained. The 50-metre terrace seems to be of Upper Pliocene age around the Mediterranean Basin. The most surprising phenomenon on the European continent is the accordance of the relative altitudes of the terraces of the Pliocene Pontic lake, in the centre of Europe in the Vienna Basin, with those of the Mediterranean coast, as Vienna is situated nearly 1000 miles from the mouth of the Danube. The speaker had shown the close relationship between the terraces near Vienna and those of the Danube at the Iron Gates near Orsova (Eastern Carpathians) and in Rumania. From Vienna the Pannonian basin extended as far as Orsova, and was separated by the Carpathians from the Pontic basin that covered the area of the Black Sea. The short valley of the Iron Gates (about 100 miles long), is the connecting-link between the terraces observed on each side of that mountain-range at the same relative altitudes above the level of the river. So it would appear that the shoreline of the Vienna Basin was only 100 miles distant from the Mediterranean Basin. Consequently, the intermittent relative subsidence of the water-level in the latter had been reproduced near Vienna as the short river cut its valley along a parallel line through the mountain-range. From 600 down to 150 feet, the terraces produced by the lake are recognizable, and later on in the lower stages those produced by the Quaternary fluvial erosion. The meaning of the similar occurrences on the Atlantic coast and in the Mediterranean Basin is not yet fully explained.

Prof. J. E. Marr congratulated the Author on having brought before the Society a paper containing valuable new facts, and such inferences therefrom as appeared to be fully justifiable, without entering into detailed comparisons between the deposits found in the area dealt with by her and other areas.

Mr. A. S. Kennard said that, with regard to the mollusca, the most important point was the discovery of *Corbicula fluminalis*. In this country it had hitherto only been known from the Thames-Rhine drainage area, but it was now shown to occur in the Severn area. The speaker wished to protest, though not with reference to this paper, against the frequent misuse of the term cold fauna; neither *Elephas primigenius* nor *Rhinoceros antiquitatis* indicated a cold climate, for these species occurred in deposits which were clearly not 'cold', and two species could hardly be termed a fauna.

The President remarked that it was usual to consider that deposition and erosion operated alternately in the formation of river-terraces; but an experience in Kathiawar had convinced him that this was not necessarily the case. Immediately after heavy rainfall in the Gir Forest a small stream became so swollen as nearly

to fill its valley some 50 feet deep and 300 or 400 feet wide. It flowed with great force in the centre, where violent stationary waves were developed, which must have resulted in powerful erosive action on the river-bed. When, however, the water subsided, a thick deposit of loam-like alluvium was found to have been laid down high up on the valley-slope.

The Author stated, in reply to Mr. Kennard, that the cold fauna of No. 2 Terrace is not merely represented by abundant remains of *Elephas primigenius* and *Rhinoceros tichorhinus*, but Reindeer is also present, together with a suite of animals of less pronounced northern type, including species of *Bos* and *Cervus*.

2. 'The Development of *Leptoplastus salteri* Callaway, and of other Trilobites (Olenidæ, Ptychoparidæ, Conocoryphidæ, Paradoxidæ, Phacopidæ, and Mesonacidæ).' By Frank Raw, B.Sc., F.G.S.

Leptoplastus salteri occurs in the Upper Tremadoc horizon of Shineton Brook (Salop). All stages of development are noted, except the protaspis.

The development is divided into successive stages, named as follows:—

Stage.	Number of segments in thorax.
(iv) Autospecific stage	12
(iii) Autogeneric stage	9 to 11
(transition)	7 to 8
(ii) Ctenopleural stage	3 to 6
(overlap)	3
(i) Heptacicephalic stage.....	1 to 3

Stage i.—The heptacicephalic stage resembles *Olenelloides armatus* Peach, in the axial elongation of all its segments, narrowness of its pleural lobes, and in possessing three pairs of head-spines. Of these, the anterior and posterior pairs, forming the antero-lateral and postero-lateral angles of the cranidium, disappear later; while the middle pair, on the free cheeks, become the genal spines.

Stage ii.—The ctenopleural stage possesses the generalized characters of the genera *Ctenopyge* and *Sphærophthalmus*.

Stage iii.—The autogeneric stage resembles the more primitive species of *Leptoplastus*: for instance, *L. ovatus* Angelin.

Stage iv.—The autospecific stage has the adult characters of *L. salteri* Callaway.

The earliest stage has a long, simply segmented glabella; long pleural spines occur throughout the body, including three pairs on

the head and four on the pygidium; while axial spines occur from the occipital segment throughout. In the last stage the glabella is short, conical, and smooth; of pleural spines, only the genal remain on the head, those in the thorax are reduced, and none remain on the pygidium, where axial spines are also wanting.

With certain reservations, these four stages are also claimed to represent successive stages in the phylogeny.

This ontogeny sheds much light on that of other trilobites, and in this way helps to reveal both their structure and their relationships.

The imperfect larval stages of other Cambrian Olenidæ agree with those of *L. salteri*, but do not reveal the anterior head-spines. They probably had a similar ontogeny. The later *Triarthrus becki* shows itself to be an Olenid.

When other trilobite ontogenies are reviewed, persistent family characters are found to mark the glabella; but all derive from a heptacicephalic ancestor. The three pairs of head-spines have in general, in the phylogeny, been reduced to one pair of genal spines. But these may be the 'posterior' pair, as in Beecher's 'Proparia'; or the 'middle' pair, as in his 'Opisthoparia'; or the 'anterior' pair, as the Author claims for the *Olenellus* family or Mesonacidæ.

The mode of life of many trilobites favoured the presence of genal spines at the postero-lateral angles of the cephalon, but only in proparial trilobites is the posterior pair retained in that position. The development of the 'middle' pair, or of the 'anterior' pair as the genal spines, involved their backward revolution through half or the whole of the length of the head respectively; at least in the phylogeny, if not still in the ontogeny. In this respect the 'Proparia' are the more primitive, and the Mesonacidæ the most specialized.

Accordingly, in the ontogenies of several families, it is the primitively posterior head-spines that at first are dominant—to be superseded later by the middle pair. In Mesonacidæ these again are succeeded by the anterior pair, which, in their lateral revolution, carried before them the anterior branches of the facial sutures, so that these cut the posterior border; they also stretched out the antero-marginal suture to the genal angle. These changes led to the supersession of the dorsal facial suture by the marginal suture, with consequent ankylosis along the former. The family is hereby claimed to have a head-structure not hitherto recognized. It illustrates a general principle—that those only of the cephalic sutures are retained as were necessary for ecdysis. Similarly, the hypostomial suture in both *Paradoxides* and the Mesonacidæ is suppressed in presence of the antero-marginal suture.

In Paradoxidæ, '*Hydrocephalus*' is claimed to be a specialized larval form of the more highly evolved or short-eyed *Paradoxides*, and to differ widely in glabella from the corresponding ancestor. In Barrande's work the ontogenies of the short-eyed *P. bohemicus*,

and *P. spinosus* can be traced from '*Hydrocephalus saturnoides*' and '*H. carens*' respectively, and the development of the more primitive long-eyed *P. rugulosus* from a more primitive larva figured by Raymond.

With these families the Author associates the proparial Phacopidæ, in which, following the loss of both 'anterior' and 'middle' pairs of head-spines, the connecting sutures (instead of the hypostomial) have been suppressed. The larval *Dalmanitina*, a Phacopid, resembles the more primitive type of *Paradoxides* larva.

The Ptychoparidæ and Conocoryphidæ in ontogeny greatly resemble one another. Their close relationship and the presence of eyes in more primitive trilobites suggest that in the Conocoryphidæ the eyes have aborted, and that this family descends from the Ptychoparidæ.

Similar to these families, especially in glabella-form, are the proparial Menomonidæ described by Dr. C. D. Walcott. The close resemblances force the conclusion that the three families (and the Calymenidæ), though including 'Opisthoparia' and 'Proparia', form a single natural order of trilobites.

The combined study of trilobite ontogeny and morphology strongly suggests, as Beecher claimed, that here the ontogeny extensively recapitulates the phylogeny; and therefore best indicates relationships. This indicates an early divergence in glabella-form, antedating divergences in cephalic spines and sutures. Members of a 'natural' order may, therefore, be expected to agree much more in glabella-form than in the cephalic suture, which has latterly been made the basis of classification.

Discussion.

Prof. H. H. Swinnerton congratulated the Author upon finding such interesting material and upon the careful way in which he had carried out his investigation. Referring to the more theoretical portions of the paper he felt that the Author attached too much importance to the cephalic spines. Such spines are a common feature in the planktonic young of recent crustacea, and their presence and strong development in the young of *Leptoplastus* and in the adult *Olenelloides* is to be regarded as associated with the mode of life in those forms. Apart from the presence of these three pairs of spines there is very little resemblance between these two genera, which have no relationship one to the other. If these three pairs of spines had any phylogenetic significance they would have occurred much more frequently in the early developmental stages of trilobites. Their occurrence is, however, the exception rather than the rule.

Among the Mesonacidæ the young of *Olenellus gilberti* alone is known to possess all three pairs of spines. The anterior pair is unknown in other Mesonacidæ, and therefore cannot have revolved

to a posterior position, as postulated by the Author. On the other hand, in *Wanneria halli* the 'middle' pair of spines actually travels from the posterior to an anterior position during development. Nevertheless, this genus, in common with all other Mesonacid genera, has no facial suture. In the general absence of both the anterior facial suture and of anterior spines in the development and in adults of Mesonacidæ, there is very little evidence in support of the Author's view that both these structures have travelled backwards to the posterior margin of the cephalon.

Prof. V. C. Illing congratulated the Author on a valuable addition to our knowledge of the development of the Trilobites. Records of the ontogeny of particular genera were all too few, and he welcomed the Author's new facts as clearing up points hitherto obscure. With regard to the more theoretical deductions, the speaker would rather adopt a more cautious attitude, in view of his own experience when dealing with isolated specimens of early development among the Middle Cambrian trilobites of Hartshill. There was a great temptation to draw analogies, which further evidence only too often falsified. At this stage of our knowledge, the speaker believed a better purpose would be served by collecting facts. His own collection of forms of *Paradoxides hicksii* confirmed and completed the evidence of the gradual forward growth of the glabella, until in the last stage the anterior margin was completely eliminated in its medial portion.

The Author, in answer to Prof. Swinnerton's criticisms, stated that reference to *Olenellus gilberti*, though it was specially illustrated by one of the slides, had been passed over in the demonstration through lack of time. *Olenelloides armatus* and the larvæ of *Olenellus gilberti*, in which the three pairs of spines were lateral in position, were regarded to that extent as reversions to the primitive condition; and this was rather supported by the fact that the lateral position of the spines was unaccompanied by any dorsal facial suture, such as occurred in the heptacicephalic stage of *Leptoplastus*. The statement that in *Wanneria halli* the genal spines had migrated from a postero-lateral to an antero-lateral position was insufficiently supported by Walcott. It was much more probable that the antero-lateral spines were the primitively anterior or procranidial spines, such as occurred in *Olenelloides* and in *Olenellus gilberti*. *Wanneria halli* was quite abnormal, and of the nature of a 'sport'.

With regard to Prof. Swinnerton's first remarks,—suggesting that the head-spines were larval accessories, and that one could not be sure of their identity—the Author replied that the definite relation observed between the cranidial and parial spines and the sutures, and the absence of any other peripheral spines besides the occipital, strongly supported the contention that they are definite morphological entities, as claimed in the paper. It had been shown that the metacranidial were the serial homologues of the pleural spines of the thorax; and they, the parial, and the procranidial, are claimed in a forthcoming paper as the serial

homologues of the macropleural spines, such as characterize the 3rd and 6th thoracic segments of *Olenelloides*. There is much evidence in favour of their being ancestral in character, and quite obviously they tended to disappear in several families in the course of evolution, the metacranidial being the last to disappear in proparial trilobites, and the parial being the last in mesoparial trilobites. This is not to say that larval conditions did not favour the persistence of the head-spines, as compared with adult conditions. As to the difficulty of identifying the different spines, this obtains solely in the Mesonacidæ, and is due solely to the disappearance of the facial suture, which receives a complete explanation in the revolution of the spines.

In reply to Prof. Illing, the Author remarked that he had purposely limited the paper to the ontogenies of the more primitive trilobites, in which the segmentation of the glabella is still evident.

Spherical flints and a bored stone from the Avon river-terraces were exhibited by Miss Tomlinson, in illustration of her paper; and an extensive series of lantern-slides was exhibited by Mr. Raw, in illustration of his paper.

The next Meeting of the Society will be held on Wednesday, November 5th, 1924.

INDEX.

Erratum.

P. 26, line 2 from top. *For* 'Bream' *read* 'Brean'.

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